Uses and abuses of paediatric electroencephalography

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Objective To investigate whether requests for standard paediatric electroencephalograms accord with guideline recommendations, subsequent changes in clinical management according to reported results, and extent to which the service meets waiting time targets.

Design Case series.

Setting Regional hospital, Hong Kong.

Patients All patients aged less than 18 years who underwent electroencephalography between December 2009 and February 2010.

Main outcome measures Appropriateness of the electroencephalogram request and the impact of its findings on clinical management.

Results A total of 109 patients were recruited, but requests for standard electroencephalograms were considered ‘inappropriate’ with respect to guidelines in 44% of the patients, of which 50% were made to diagnose ‘funny turns’. The standard electroencephalogram contributed to the diagnosis or management in only 28% of patients. In all of the latter, the request for an electroencephalogram had been appropriate. Non-specialists made referrals for 86% of the patients. Inadequate information was provided in 66% of the requests. Standard electroencephalograms were performed within guideline targets, the wait being less than 4 weeks in 95% of requests.

Conclusion An effective electroencephalogram service was being provided, though abuses were common. These were mainly because of misconceptions regarding the role and limitations of standard electroencephalograms. Through an educative, non-confrontational approach, and with time to explain guideline recommendations to clinicians, sustainable change in practice could be achieved so as to benefit patients, clinicians, and service provision.

Key words
Child; Electroencephalography; Hospitals, district; Practice guidelines as topic; Utilization review

Introduction
Electroencephalogram (EEG) has gained a reputation as a diagnostic test with a range of indications. “Uses of EEGs” amount to “abuses of EEG” if the roles and limitations of standard EEGs are not clearly appreciated. There has been unrestricted access to standard EEGs in most Hong Kong hospitals. Most requests are from non-specialists. Hence, there is considerable potential for unnecessary requests and misinterpretation of the results.

New knowledge added by this study
* Misconceptions about the diagnostic capability of standard electroencephalogram (EEG) in paediatrics are common.
* Approximately 44% of corresponding standard EEG requests were deemed ‘inappropriate’ with respect to guidelines, of which 50% were to yield a diagnosis ‘funny turns’, 23% in patients with febrile convulsions, 23% as a form of monitoring in persons with established epilepsy.
* Requests made appropriately were highly associated with EEG results that were contributory to clinical management.

Implications for clinical practice or policy
* The EEG can support the diagnosis and classification of epilepsy in an appropriate clinical context.
* The standard EEG was not helpful (or even misleading) when requests were inappropriate.
The aims of this study were to evaluate use of the paediatric EEG service with respect to: (1) whether standard EEG requests were appropriate (according to guideline recommendations), (2) whether subsequent changes in clinical management according to reported findings were appropriate, and (3) to what extent the service met waiting time targets.

Methods
All children aged less than 18 years who underwent standard EEGs between December 2009 and February 2010 in Tuen Mun Hospital were identified. Tuen Mun Hospital is the only regional hospital that provides EEG services to the paediatric population in the northwest section of Hong Kong. Requests for EEGs and clinical notes were reviewed. On the request forms, doctors need to explicitly state a provisional diagnosis, provide clinical information and the purpose of the examination. Purposes for EEG requests were classified as ‘appropriate’ or ‘inappropriate’ according to international guidelines and published expert opinion (Table 1).3-6 Results of EEG were defined as normal, non-specifically abnormal, epileptiform and specific findings such as encephalopathic. The potential contribution of the EEG to management was ascribed to one of the three categories (Table 2).7 Data were analysed using IBM SPSS Statistics version 19.0.0 using Pearson’s Chi squared test.

Results
A total of 109 patients were recruited; 44% of standard EEG requests were considered ‘inappropriate’ with

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<td>Epilepsy</td>
<td>‘Funny turn’</td>
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<td>Definite/probable epilepsy/seizure</td>
<td>Established epilepsy—clinical change in seizures with the exception of absence</td>
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<td>Classify newly diagnosed epilepsy</td>
<td>Febrile convulsion</td>
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<td>Established epilepsy: subclinical EEG changes leading to symptoms</td>
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respect to guidelines, of which 24 (50%) were for the diagnosis of ‘funny turns’—11 (23%) for febrile convulsions, 11 (23%) in persons with established epilepsy using EEG as a form of monitoring, and two (4%) where no reason could be identified (Table 3). Of the 61 appropriate requests, 54 (89%) were to support a diagnosis of epilepsy, when there was a strong clinical suspicion of epilepsy.

Findings of EEG were as follows: normal in 65 (60%), epileptiform in 22 (20%), encephalopathic in 13 (12%), encephalopathic and epileptiform in 4 (4%), and non-specific in another 5 (5%). The EEG contributed to the diagnosis or management in only 31 (28%) of the cases; for all of these patients the requests were appropriate (Table 4). The EEG was not contributory to clinical management in all inappropriate requests. Thirty (49%) of the 61 appropriately requested EEGs were not contributory to the management. There was a highly significant association between EEG results contributory to clinical management and whether the request was made appropriately (P<0.001). Non-specialists made referrals in 94 (86%) of cases, of which 42 (45%) were inappropriately requested. Specialists made 15 referrals and only nine (60%) were considered appropriate. However, the proportional difference in appropriateness between the two groups was not statistically significant (P=0.735).

The purpose for requesting EEGs was not provided in 40% of requests. When it was stated, 26 (40%) of requests were considered inappropriate. Information was inadequate in 66% of EEG referrals. When requested, EEGs were performed within 2 days in 85% of in-patients and 95% met the guideline target wait of 4 weeks.

**Discussion**

We demonstrated that almost half of the standard paediatric EEG requests were inappropriate, mainly because of misconceptions about its role and limitations. If the requests are made improperly or with insufficient information, they could be regarded as an abuse of the EEG service. The EEG service could be considered useful in that it confirmed the diagnosis or altered management, although only about one-quarter of all instances were appropriately requested. Resorting to standard EEGs could be regarded as unhelpful or even potentially misleading in all instances of inappropriate requests. We believe the use of our EEG service is typical of that encountered in most regional hospitals in Hong Kong, and our results can probably be generalised.

Electroencephalogram requests were considered to be inappropriate because of the misconceptions about its uses in various clinical settings, notably in patients with ‘funny turns’. One of the commonest abuses was ‘to exclude epilepsy’, which is almost impossible, as the diagnosis of epilepsy being clinical. In the majority of patients with funny turns, interictal EEGs are indistinguishable from normal findings. Moreover, so-called false-positive EEG findings can be as high as 0.5%, if there are no clinical features to suggest epilepsy. This increases the risk of misdiagnosing epilepsy and its attendant important consequences, including inappropriate drug treatment and the psychological trauma of being ‘labelled’ epileptic. Linzer et al systematically reviewed 534 EEGs performed in eight studies on syncope. They were diagnostic in only 1.5% of instances, out of which one-quarter had a history of seizures. The guidelines recommend EEG as ‘a diagnostic tool’ if seizure activity is present...
Based on the clinical history and physical findings. Moreover, patients who have had seizure activity, yet normal findings on EEG, no postictal symptoms, and no response to anticonvulsant medications should be evaluated for possible cardiac syncope.9

Provided one recognises that a normal routine EEG does not exclude its diagnosis, it can play a major role in evaluation of epilepsy3-5 by supporting the diagnosis and aiding classification of epilepsy in a proper clinical context. Classification of epilepsy into seizure types and syndromes is important because prognosis and treatment can vary in different epileptic syndromes. Localising EEG features can often raise suspicion of intracranial pathology that requires subsequent confirmation by neuroimaging. The sensitivity of a single interictal EEG is not high. Routine EEG recorded in patients with epilepsy yield no epileptiform activity in about 50% of cases.10,11 Marsan and Zivin11 reviewed 1824 EEGs in adults with epilepsy; one-fifth never exhibited epileptiform discharges in the course of repeated EEG examinations, half showed epileptiform discharges on some occasions, and only 30% yields epileptiform discharges consistently.

Standard EEGs are considered helpful in predicting the risk of recurrence after a first seizure, and if abnormal it is becoming more common to treat patients even after one seizure. The risk of relapse is increased if the EEG shows generalised spike-wave discharges.6,12 Moreover, EEGs can help in the evaluation of encephalopathies (metabolic, infectious, and degenerative) and focal brain lesions (cerebral infarction, haemorrhage, neoplasms). In paediatric practice, they might help to determine the level of brain maturation.5 In the management of status epilepticus, EEGs are helpful indicators of treatment efficacy, depth of anaesthesia, and whether the patient is in status epilepticus, especially when it comes to disentangling symptomatic epilepsy and behavioural change.5,13 By contrast, EEGs are not useful in following the therapeutic efficacy of antiepileptic drugs, except in absence epilepsy where quantification of spike-wave episodes is helpful in monitoring treatment impact.5,6,13

The proportion of inappropriate EEG requests noted in present study was comparable to that reported by Smith et al,2 who retrospectively evaluated 368 patients who underwent EEG in a district general hospital, and found 56% of the testing to be inappropriate (based on similar guidelines available at that time). Similarly, according to an audit performed in a general paediatric service, two-fifths of EEG requests were considered inappropriate.1 Pearce and Cock1 reported a lower rate of 26% inappropriate requests in an audit at neurology/neurosurgery referral centre. Neurologists/epileptologists appeared better than non-specialists in terms of appropriate referrals.2

Standard EEG contributed to management in only 28% of instances in the present study, of which the figure is similar to the rate of 22% reported by Pearce and Cock.7 Binnie16 observed that 60% of referrals were “routine EEG to assess control” in patients with epilepsy and found that results influenced management in only 3% of instances, and 40% when the referral policy was changed. Smith et al7 reported that when the number of inappropriate requests decreased, the number of ‘useful’ EEGs increased. We also found that appropriate requests were more likely to result in ‘useful’ EEGs and ‘useless’ ones were more likely after inappropriate referrals.

This study also evaluated target waiting times. Investigations by EEG are more sensitive when performed early15,16, and should be performed within 4 weeks of any requests made according to recommended guidelines.14 We demonstrated that an effective service has been provided, because 95% met the target waiting times, though sustainability may be questioned if abuses are common. Strategies to decrease inappropriate requests are required to optimise service utilisation. Restructuring of request forms, coupled with changes in referral policy, should be considered.

A limitation of our study was the non-inclusion of sleep-deprived EEG. Previous studies have shown that sleep deprivation in children can increase the diagnostic yield by as much as 35%.17,18 The release of potential technical capacity from reduction of inappropriate request can be better used for sleep-deprived EEG and telemetry services.

Non-confrontational and educative approaches (presenting audit findings, guideline sharing) may help reduce unnecessary requests. The greater understanding of the limitations and roles of EEGs may reduce the risk of misdiagnosing epilepsy.

References

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